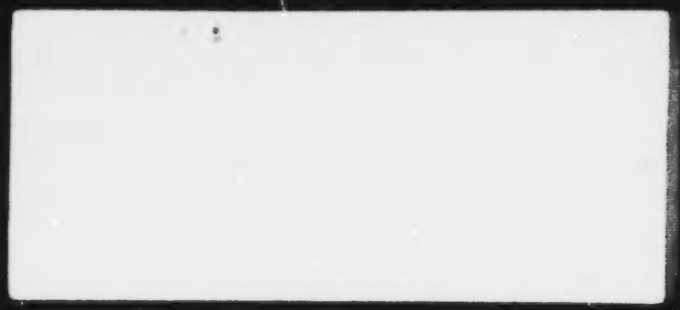
Final Report



A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

MADAWASKA REGIONAL CORRECTIONAL CENTER
WOODCHIP FIRED BOILER AND AUXILIARIES
MADAWASKA, N.B.

March 8, 1985

CREDA Project # 2006

Sponsored by:

Department of Supply and Services
Province of New Brunswick

Report Compiled by:

Cregory Cook

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

Conservation & Renewable
Energy Division
Energy Secretariat
P.O. Box 6000
Fredericton, N.B.
E3B 5H1
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Programme Canada/Nouveau-Brunswick de démonstration des économies d'énergie et des énergies renouvelables

Le Programme de démonstration des économies d'énergie et des énergies renouvelables est administré au Nouveau-Brunswick par le Secrétariat à l'énergie, en collaboration avec Energie, Mines et Ressources Canada. Ce programme tente d'abord de vérifier la fiabilité des techniques de conservation d'énergie, d'accroître la sensibilité du public envers ces techniques et, enfin, de favoriser la création d'emplois au sein des industries nouvelles ou déjà existantes.

Un grand nombre de projets de démonstration se sont avérés à la fois techniquement réalisables et économiquement attrayants.

Le succès ainsi rencontré encourage la commercialisation des procédés les plus accessibles. Cela entraînerait certes l'adoption d'un grand nombre de ces techniques par les propriétaires de domiciles et par l'industrie privée.

Ce rapport final est basé sur un projet qui a reçu une aide financière du Programme de démonstration. Pour de plus amples renseignements, communiquez avec la:

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et des énergies renouvelables
Secrétariat à l'énergie
C.P. 6000
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D I S C L A I M E R

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D E N I D E R E S P O N S A B I L I T E

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EXECUTIVE SUMMARY

A waste-wood fired heating system was installed at the Madawaska Regional Correctional Center, St. Hilaire, N. B. to demonstrate that:

(i) it is both technically and operationally feasible to use wood-waste as a source of fuel to provide for the heating and domestic hot water requirements of the facility.

(ii) it is cost effective to use wood waste (a renewable energy resource) to replace high cost No. 2 heating oil (a non-renewable energy rescurce).

The fully automated heating system utilizes a fuel mixture of hardwood chips and sawdust (40/60 ratio) having an average moisture content between 35 and 40% on a wet basis.

The system was commissioned in December 1982 and has continued to operate without any major problems since that time.

Our experience with this project has convinced us that woodburning technology has "come of age" and that there are ample opportunities where projects of this nature can be duplicated. We have been impressed by the simplicity of the system operation and the lack of operator attention that is required to supervise and maintain the system.

The objectives of our demonstration project have been adequately realized, and it has been shown that significant savings in fuel costs can be achieved by burning wood residue instead of No. 2 oil.

The installation of the wood fired boiler at this institution has resulted in an annual saving in fuel costs of approximately $ 39,000.00, by using 524 tonnes of wood chips and sawdust to replace 132,132 liters of No. 2 heating oil. At current fuel costs this represents a saving of approximately 75%.

SOMMAIRE-RECOMMANDATION

Une installation de chauffage aux résidus forestiers fut aménagée au centre correctionnel régional du Madawaska, à Saint-Hilaire (N.-B.), pour démontrer que:

i) Il est à la fois techniquement et pratiquement faisable d'utiliser des résidus forestiers comme combustible pour le chauffage des locaux et de l'eau domestique dans ce genre d'établissement;

ii) il est rentable d'utiliser des résidus forestiers (une source d'énergie renouvelable) pour remplacer le mazout nº 2 (une source d'énergie non renouvelable) dont le coût est élevé.

Le système de chauffage entièrement automatique utilise un mélange de sciure et de copeaux de feuillus (rapport de 60/40) dont la teneur en humidité moyenne se situe entre 35 et 40 % (poids humide).

Le système a été mis en service en décembre 1982 et a continué de fonctionner sans aucun problème majeur depuis ce temps.

Notre expérience avec ce projet nous a convaincu que la techonologie de la combustion du bois est maintenant "chose du présent" et que ce genre de projet peut s'adapter à un grand nombre d'installations semblables. Nous avons été impressionnés par la simplicité que la surveillance et l'entretien peuvent exiger de la personne responsable du chauffage.

Les objectifs de notre projet de démonstration ont été atteints de façon satisfaisante et on a pu constater que d'importantes économies de chauffage peuvent être réalisées par la combustion de résidus forestiers en remplacement du mazout nº 2.

L'installation d'une chaudière au bois dans cet établissement a permis deséconomies annuelles des coûts du combustible de près de 39 000 $, soit par le remplacement de 132 132 litres de mazout nº 2 par 524 tonnes de sciure et de copeaux de bois. Selon les coûts actuels du combustible, ceci représente des économies de près de 75%.

INTRODUCTION AND BACKGROUND:

The interest in installing a wood fired boiler at the Madawaska Regional Correctional Center was first proposed after learning that the P.E.I. Department of Justice were planning to install a unit at one of their correctional facilities (Sleepy Hollow Correctional Facility) just outside of Charlottetown, P.E.I. Our original submission for funding under the C.R.E.D.A. Program called for the unit to be installed at the Saint John Regional Correctional Centre. As a result of difficulties in trying to secure a long term, low cost supply of fuel we requested and were granted permission to relocate our project to the Madawaska facility.

The decision to proceed with the demonstration project was made very late during the construction stage of the correctional facility. The existing heating system had been installed and there was no way of incorporating the new wood burning system into the existing building. As a result we had to construct a new boiler house for the wood burning system remote from the facility and to connect the woodburning unit to the existing building system via underground lines. The necessity for having to build the new boiler house had a significant impact on the capital cost of the project. One advantage of the remotely located boiler house however was that we were able to locate it to take advantage of a side hill location which greatly aided us in the fuel handling aspects of the project.

The performance objectives of the demonstration project were two-fold, namely:

(i) to demonstrate that it was feasible and cost effective to burn waste wood products to provide heat and hot water for an institutional facility.

(ii) to use a renewable energy resource (chips/sawdust) to replace a non-renewable energy resource (No. 2 heating oil).

A considerable amount of investigative work was carried out in order to develop adequate specifications for the type of system to be used in this demonstration project. Once specifications were completed public tenders were called for the complete wood burning system including bin unloading mechanism, fuel transport systems, fuel cell, boiler, ash and dust collection equipment, stack, controls, etc. We felt that it was imperative that the complete system was purchased from one manufacturer. The lowest priced tender, having met the specifications, was accepted.

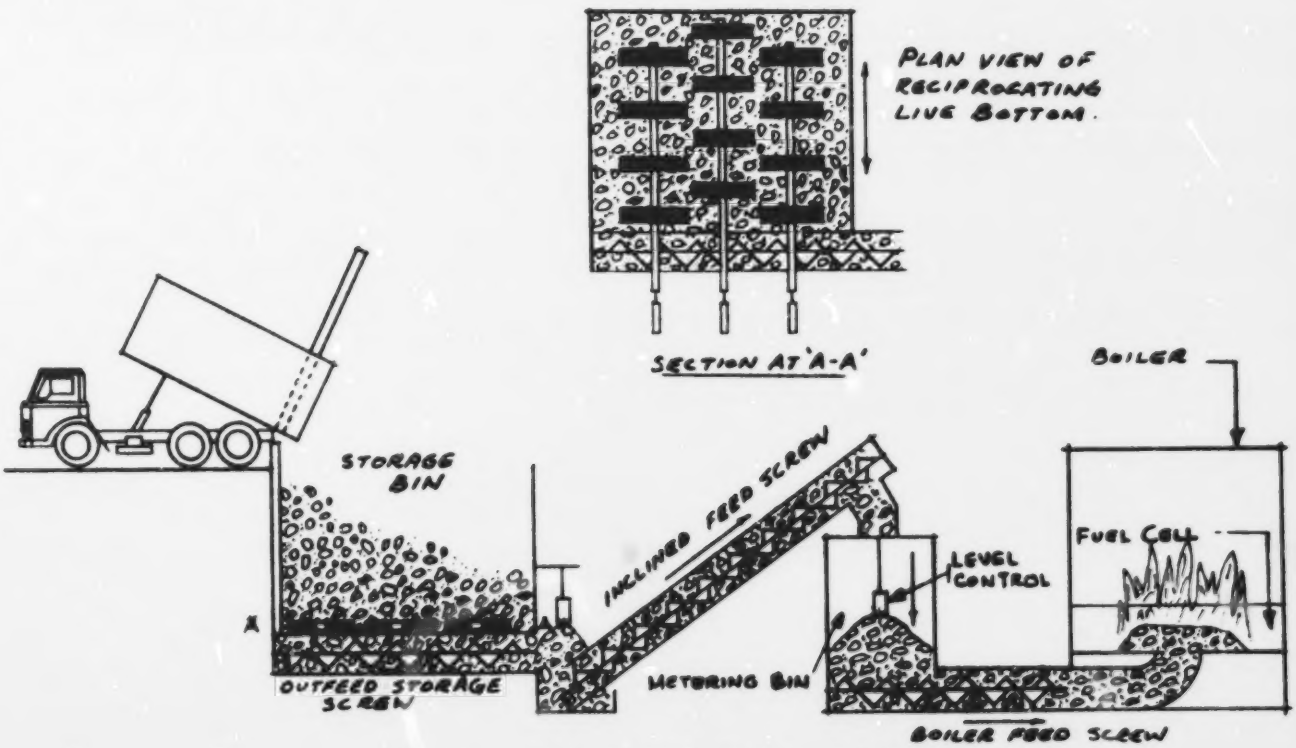
The primary purpose of this project was not to save energy but rather, as stated earlier, to utilize an alternate source of energy. Through this demonstration project we were able to achieve this objective while at the same time significantly reduce our operating costs for heating fuel.

Our experience with this project has convinced us that there are a number of opportunities where similar systems could be installed. The most likely locations would be in medium to large sized institutional and industrial facilities where there is sufficient heating load on a year round basis. The feasibility of installing systems much smaller than our demonstration project (50 b.h.p.) would be questionable.

As a result of our positive experience with this unit we are proposing to install a similar although somewhat larger unit in one of our other complexes.

DESCRIPTION OF DEMONSTRATION

The following schematic diagram outlines the basic fuel handling sequence used in this demonstration project:



FUEL FEEDING FLOW DIAGRAM

Fuel is delivered to the wood burning facility in tandem-type dump trucks. Because the boiler house is located on a side hill the bin was constructed below grade level to allow the trucks to dump directly into the bin without any need for intermediate handling and conveying of the fuel mixture.

The bin unloading mechanism consists of a reciprocating live bottom hopper system that consists of three hydraulically operated rams fitted with cross flights designed to draw back easily under the pile and then to push the material forward on the return stroke. A screw conveyor on the discharge end of the storage bin collects the fuel and transports it, on demand from a level controller, to the inlet of the inclined screw feed. From there the fuel mixture travels up the inclined screw feed where it is deposited into the fuel metering bin. The level of fuel in the fuel metering bin is maintained by a level controller that stops and starts the inclined feed screw. When there is a demand on the boiler for heating, the boiler feed screw delivers fuel from the metering bin to the fuel cell where primary combustion takes place. The fuel cell is underfed with the fuel spread out over a flat burning surface. Under and overfire air provide controlled combustion within the fuel cell. The system responds to the demand of the "heat users" by firing with induced draft and combustion air. "Low fire" will result when demand decreases. During this cycle all fans are down and fuel is delivered to the cell only in sufficient quantities as to maintain the temperature and operation of the furnace.

Ashes are removed from the cell by raking the grate area and depositing them in a special ash transport screw where they are conveyed from the boiler room. The boiler for this system is of a three-pass design, and it is positioned above the fuel cell. The boiler generates low temperature hot water (88°C) and is connected directly to the building heating and domestic hot water systems via underground lines running from the wood boiler house to the boiler room in the penthouse of the main facility.

Gases leaving the boiler are cleaned in a cyclonic ash collector. An air lock valve discharges fly ash to the main ash screw where it is transported out of the boiler room. The induced draft fan draws gases from the cell to maintain a negative pressure condition through the gas travel course. This fan operates only during high fire cycle.

OBSERVATIONS DURING INSTALLATION AND MONITORING

As mentioned earlier the entire wood burning system was purchased in advance as a complete package. This package was then incorporated into the overall project design (site work, electrical, mechanical, architectural aspects etc.) and tenders were called for construction by the General Contractor. No major problems were encountered during the construction phase of the project. This was the result of the manufacturer having done most of his assembly in the shop prior to shipment thereby requiring a minimal amount of field erection. In our opinion the lack of problems on this project were the direct result of the manufacturer's attention to the detailed engineering of his complete system.

When construction was completed the supplier of the wood burning equipment was brought on site to commission and start up the system and to train the maintenance staff on the operation and maintenance of the unit.

One of the most surprising lessons that we have learned from this project is the lack of attention that the unit requires, both from an operational and maintenance point of view. The unit operates automatically and quite often will go for days without even being checked on. Our maintenance personnel state that the wood fired boiler system requires less attention than the oil fired boilers they are used to working on.

The only problems we have had with the unit to date have been caused by the occasional "slab" of wood that sometimes shows up in the fuel supply causing the feed screw mechanism to jam. When this happens an indication light is alarmed in the main control room of the institution to alert maintenance personnel to the problem.

During the two years that the unit has been operating we have not had to shut the unit down except to carry out minor repairs (replace safety valve, cleaning of boiler tubes etc.). The reliability of the system is such that our operating personnel now regard the system in the same light as the oil fired systems (i.e. there is nothing magic about burning wood any more.)

COST BENEFIT ANALYSIS:

A) **CAPITAL COSTS:**

Construction Contract -

Generalities	$ 29,000.00	
Site Work	$ 2,115.00	
Concrete	$ 38,385.00	
Unit Masonry	$ 4,700.00	
Structural Steel	$ 17,200.00	
Metal Siding & Insulation	$ 31,520.00	
Doors and Windows	$ 8,250.00	
Specialties	$ 1,545.00	
Mechanical	$ 41,335.00	
Electrical	$ 17,950.00	
TOTAL		$ 192,000.00

Major Equipment Purchases -

Bin Unloading System	
Fuel Transport System	
Boiler (50 h.p.)	
Fuel Cell	
Ash Removal System	
Dust Collection System	
Fans	
Stack	
Ash Transport System	
Electric Power & Control Cabinet	$ 77,000.00
TOTAL PROJECT COST	$ 269,000.00

Funding Arrangements -

C.R.E.D.A. Grant	$ 170,000.00
N.B. Dept. of Supply & Services	$ 99,000.00
TOTAL	$ 269,000.00

B) OPERATING COSTS

(i) Annual fuel consumption prior to installation of wood fired boiler (No. 2 Oil)

MONTH	QUANTITY
January	18,639 liters
February	25,458 liters
March	14,547 liters
April	7,274 liters
May	10,865 liters
June	5,000 liters
July	2,728 liters
August	7,274 liters
September	7,274 liters
October	14,093 liters
November	18,639 liters
December	22,275. liters
TOTAL	154,066 liters

(ii) Annual Fuel Consumption after installation of wood fired boiler.

MONTH	QUANTITY	
	WOOD CHIPS/SAWDUST	OIL
January	81,818 Kg	Ø liters
February	47,727 Kg	Ø liters
March	85,000 Kg	Ø liters
April	88,636 Kg	Ø liters
May	57,273 Kg	Ø liters
June	20,455 Kg	1,364 liters
July	Ø Kg	2,273 liters
August	Ø Kg	2,500 liters
September	Ø Kg	6,819 liters
October	6,818 Kg	8,978 liters
November	61,364 Kg	Ø liters
December	75,000 Kg	5 liters
TOTAL	524,091 Kg (524 tonnes)	21,934 liters

- Quantity of No. 2 Oil displaced in twelve month period. = 132,132 liters

- Quantity of wood residue burned in twelve month period. = 524,091 Kg

- Value of oil displaced

  @ $ 0.390 per liter

  (January 1985 prices) = $ 51,531.00

- Value of wood burned

  @ $ 24.00 per tonne

  (January 1985 prices) = $ 12,578.00

  Annual Fuel Cost Saving $ 38,953.00

PAYBACK PERIOD (Simple):

Capital Cost = $ 269,000.00

Annual Fuel Saving = $ 38,953.00

$$\text{Payback Period} = \frac{\text{Capital Cost}}{\text{Annual Fuel Saving}}$$

$$\text{Payback Period} = \frac{269,000}{38,953} = 6.9 \text{ years}$$

C) HEATING COSTS - WOOD vs OIL

Using the figures in the foregoing calculations we see that the cost ratio of providing heat energy using wood as a fuel compared to No. 2 oil is as follows:

$ 12,578. : $ 51,531. = 0.24

In other words the cost to produce heat energy using wood as a fuel is 24% of the cost to produce the same amount of heat using No. 2 Oil.

CONCLUSION:

The overall objectives of this demonstration project have been realized and as such we feel that the overall project has been a success. The pay back period turned out to be somewhat higher than we would have liked. This was due in part to the following factors:

(i) The unit is relatively small and the total quantity of fuel required (approximately 525 tonnes per year) was considerably less than originally calculated in the design of the building heating loads. The opportunities for pay back improve as the quantity of fuel burned increases.

(ii) The unit was built after the main correctional facility was constructed. As a result the total project cost was incremental whereas considerable savings could have been realized had the system been incorporated into the design of the main complex when it was built.

This demonstration project has effectively shown that burning wood is no more difficult or unreliable than using oil fired heating systems. The plant has been operating for a period in excess of two years and no significant problems have been encountered to date.

The experience that has been gained from this project has convinced us that similar systems should be considered at other institutions and/or facilities where there is sufficient heating loads to justify the capital expenditures required to install the system and where a readily available source of low cost wood fuel can be secured.

As a result of our positive experiences with this system we are proposing to install a larger system (100 h.p.) at one of our other facilities in the Fredericton area.

During the period that we have been operating this system a number of groups and individuals have visited the project to view the demonstration project and in all instances have been impressed by the unit's operation.

RECOMMENDATIONS:

The following recommendations are proposed as a result of our experiences with this project.

1. The wood fired systems should be installed in new installations if possible to reduce the incremental capital cost of the project.

2. When replacing existing systems every effort should be made to house the wood fired units in existing facilities so that the capital cost of the project can be kept as low as possible in order to reduce the pay back period.

3. Extra care should be taken to ensure that the wood fired unit is sized to match the building and/or process heating loads as close as possible. One of the problems with a number of installations is that the wood fired units are oversized resulting in operation at low load for a considerable portion of the time. This results in a loss of efficiency and poor combustion during "low fire" periods.

4. We have no recommendations for improving on system design as a result of our experience. The system has worked beyond our expectations.

5. When installing a wood burning unit ensure that all components are purchased from one manufacturer so that responsibility for the entire system operation can be enforced.

6. With regard to site erection we feel that as much fabrication and assembly as possible should be carried out in the shop prior to shipping to the job site. This will reduce the time required for site erection and also expose problems that might later develop on the site.

INFORMATION TRANSFER:

Our project generated a considerable number of inquiries and visitors during the past two years. Probably the most difficult task we had was convincing these people that the unit operated as automatically and as trouble free as our experiences had proven. As a result of our project a number of people have expressed an interest in installing similar systems.

A number of newspapers and periodicals (including MacLeans Magazine) have published articles about our project. In addition the New Brunswick Information Service has prepared a video tape presentation that was aired on local television.

LIST OF APPENDICES

1. Fuel Analysis Reports for Moisture Content and Heating Value.
2. Drawing - Showing Boiler House Floor Plan and Elevations.
3. Various Photographs of Equipment and Boiler House.

Report Number: C/83/196 January 23, 1984

Job Number: 60532/4

Mr. Greg Cook
Department of Supply and Services
Room 450
Centennial Building
P. O. Box 6000
Fredericton, N. B.
E3B 5H1

Analysis of Wood "Chips"

Chemistry Codes 83/1172 and 83/1173

On December 14, 1983 two buckets of wood "chips" were delivered to RPC for determination of moisture and gross heat of combustion.

Results

Chemistry Code	Sample Data	Moisture (%)	Gross Heat of Combustion BTU/lb.	
		as received	as received	100% dry
83/1172	White bucket	36.7	5267	8320
83/1173	Yellow bucket	40.3	4967	8320

Derek R. Kirby,
Laboratory Manager,
Chemistry Department.

Dr. Peter J. Silk, Head,
Chemistry Department.

rpc

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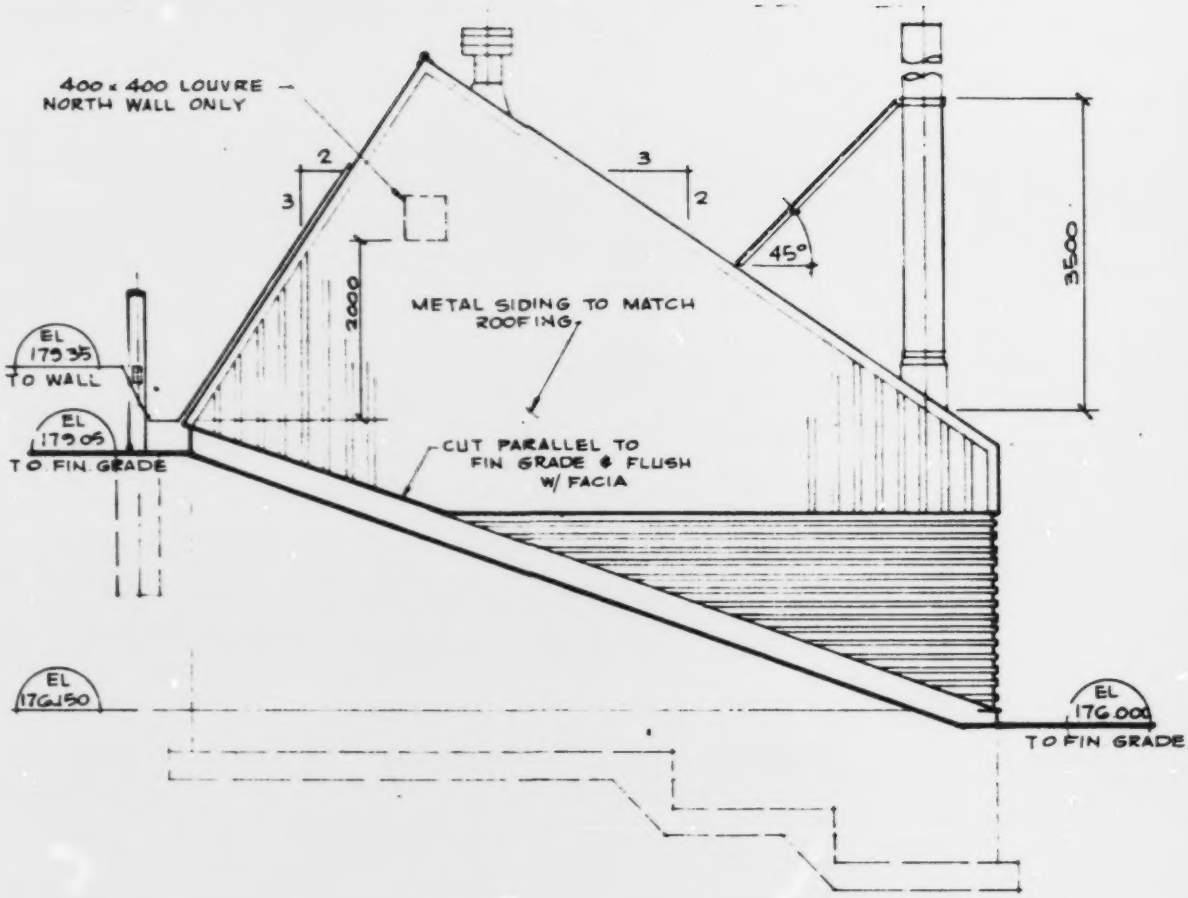
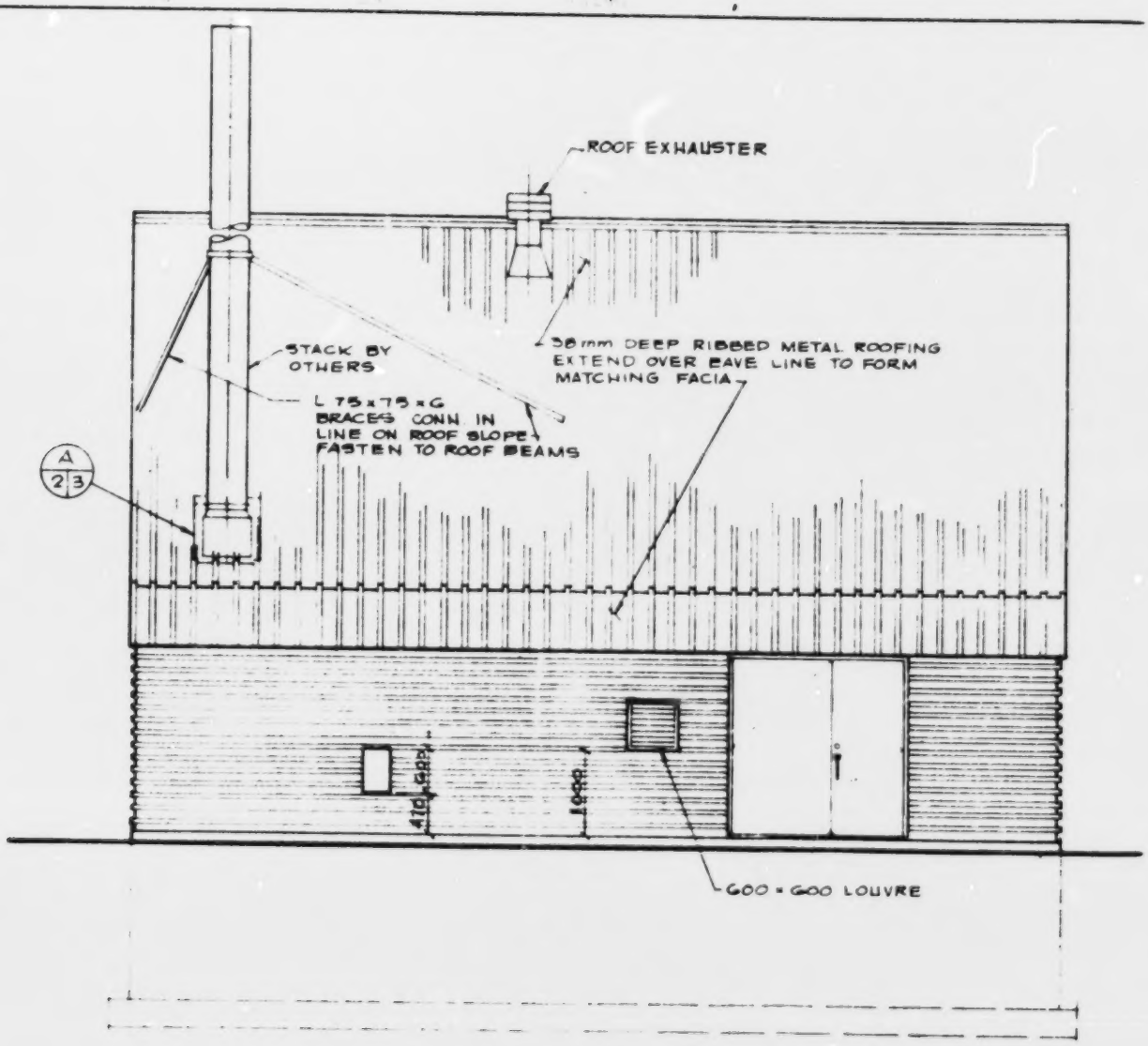


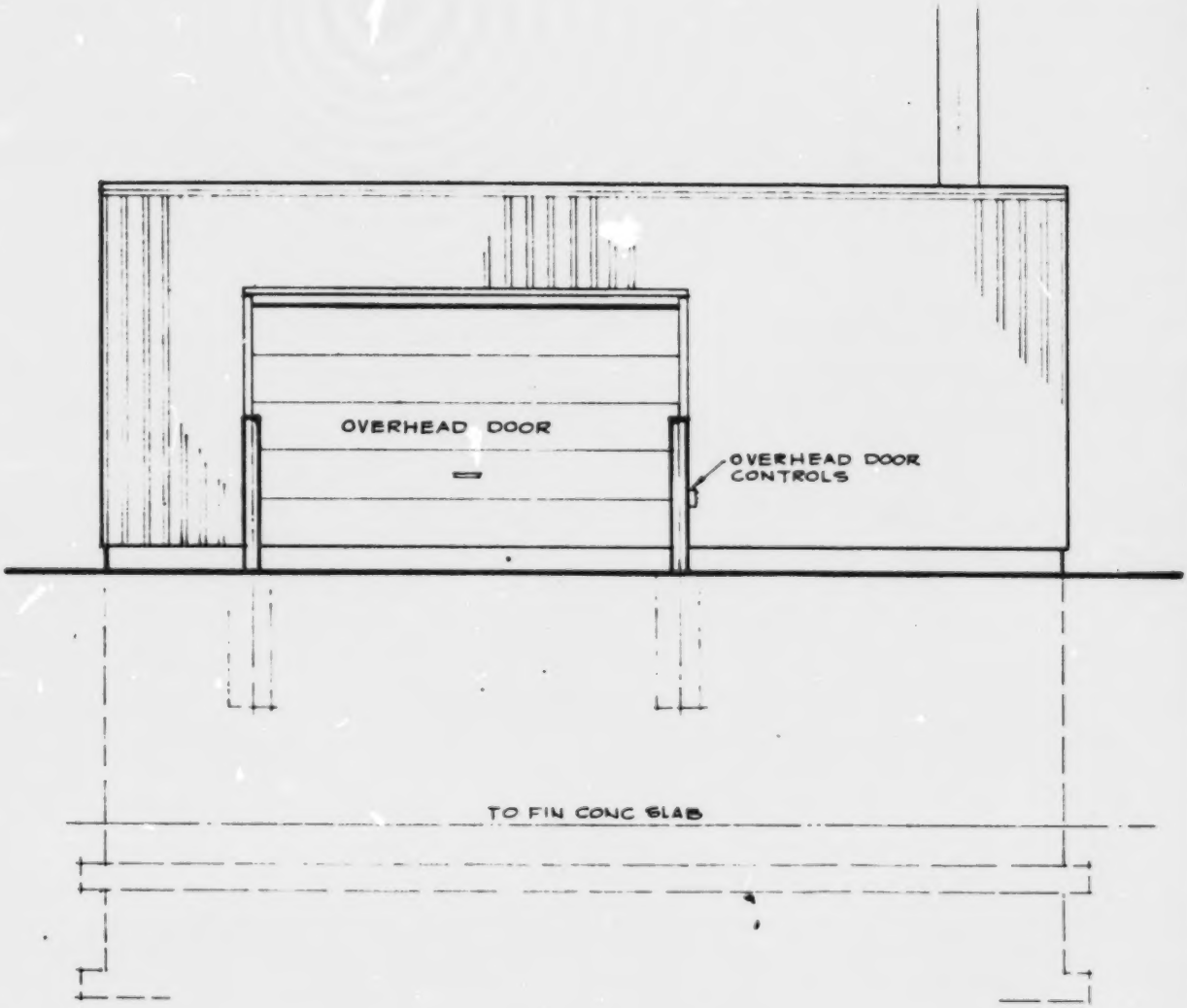
SOUTH ELEVATION
(NORTH ELEVATION SIMILAR)

ADI Limited
Engineers Architects
Management Consultants
Planners Surveyors

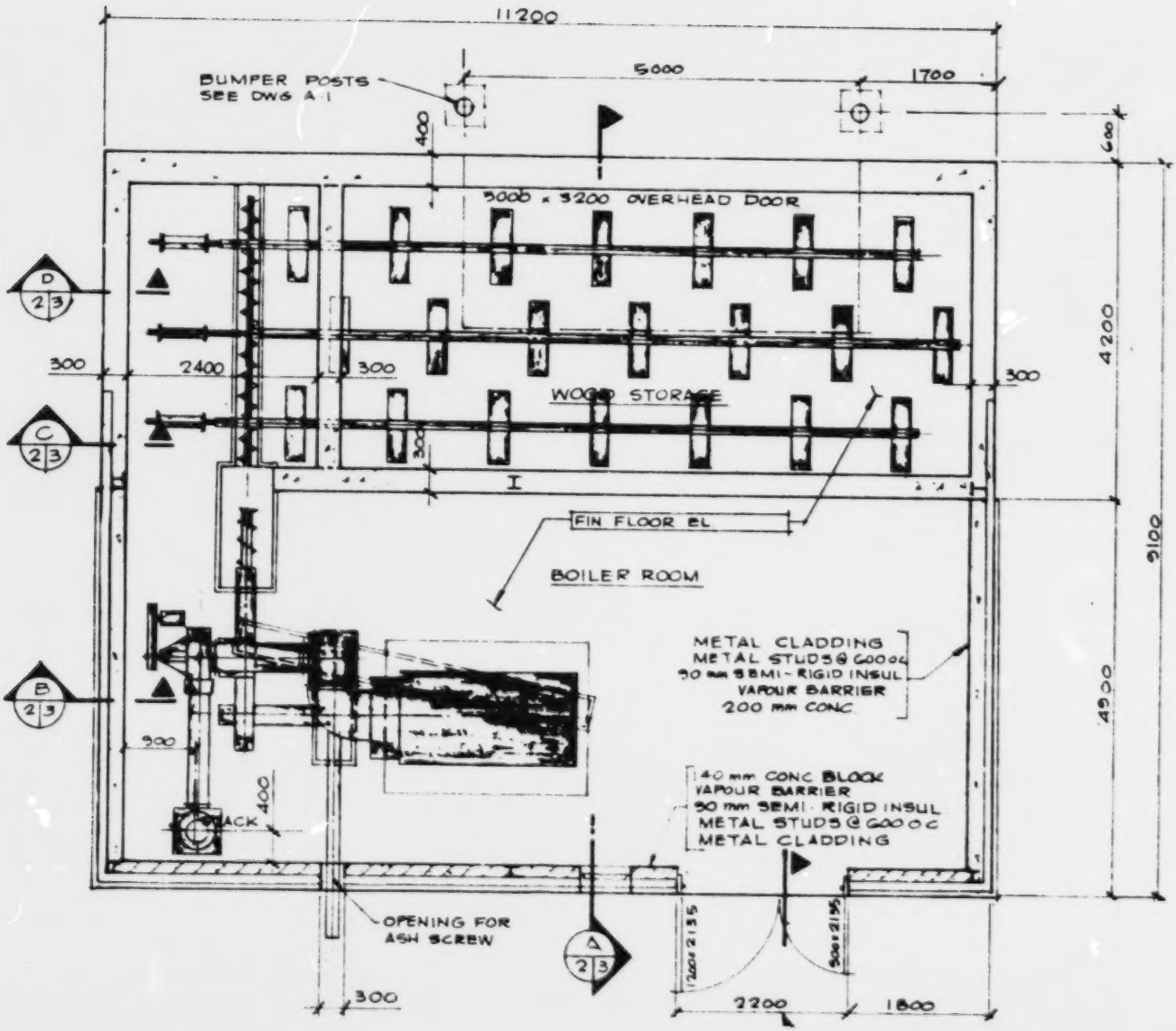
A-2	
001	001
004	004
005	005


ROOF EXHAUSTER
38mm DEEP RIBBED METAL ROOFING EXTEND OVER EAVE LINE TO FORM MATCHING FACIA
STACK BY OTHERS
L 75x75x6 BRACES CONN IN LINE ON ROOF SLOPE FASTEN TO ROOF BEAMS
A
2 3
600 x 600 LOUVRE

EAST ELEVATION



WEST ELEVATION


11200
BUMPER POSTS
SEE DWG A-1
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D
2 3
C
2 3
B
2 3
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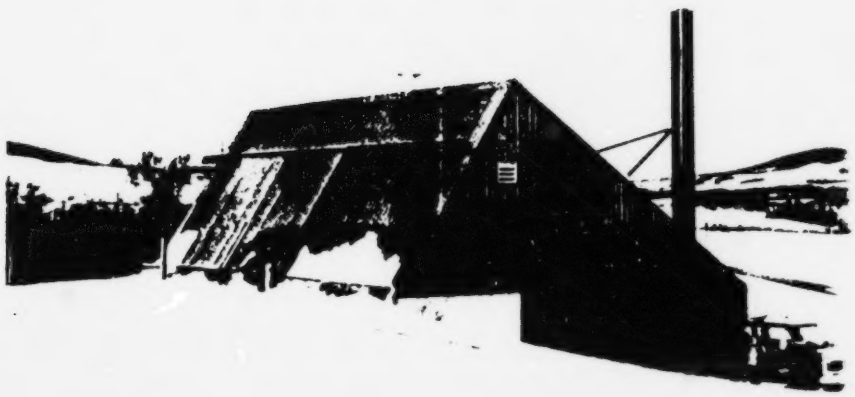
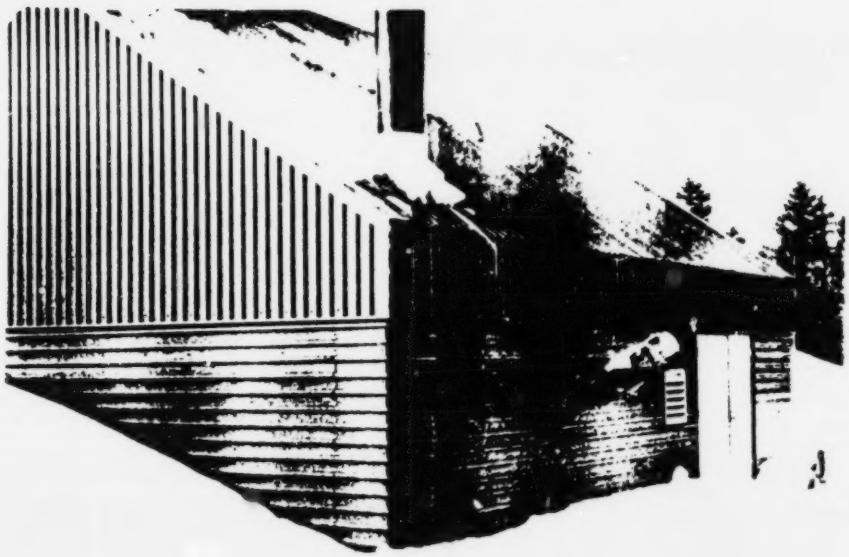
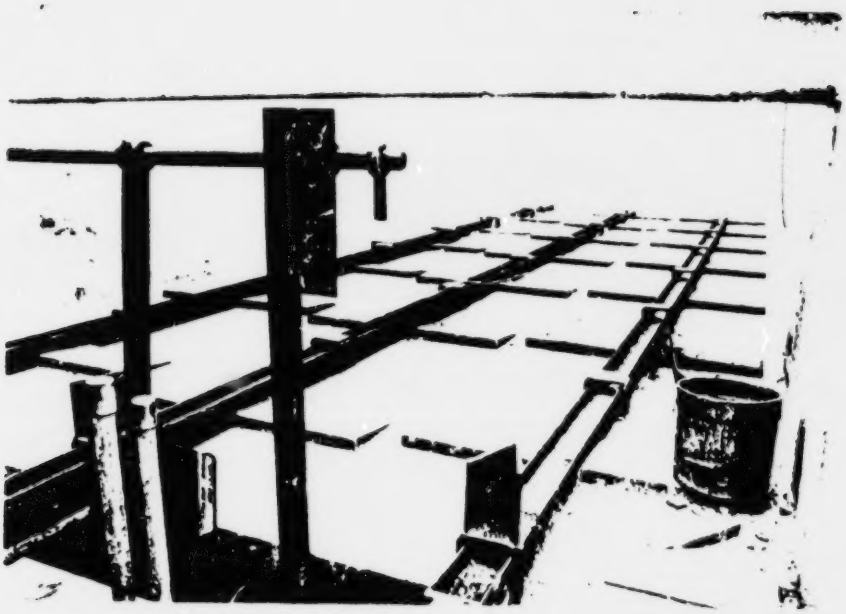
2400
300
WOOD STORAGE
300
4200
I
FIN FLOOR EL
BOILER ROOM
9100
METAL CLADDING
METAL STUDS @ 600 oc
90 mm SEMI-RIGID INSUL
VAPOUR BARRIER
200 mm CONC
4900
900
400
BACK
40 mm CONC BLOCK
VAPOUR BARRIER
90 mm SEMI-RIGID INSUL
METAL STUDS @ 600 OC
METAL CLADDING
OPENING FOR
ASH SCREW
A
2 3
300
2200
1800



VIEW OF BOILER HOUSE SHOWING BIN LOADING DOORS



VIEW OF BOILER ROOM SHOWING ASH DISCHARGE SCREW

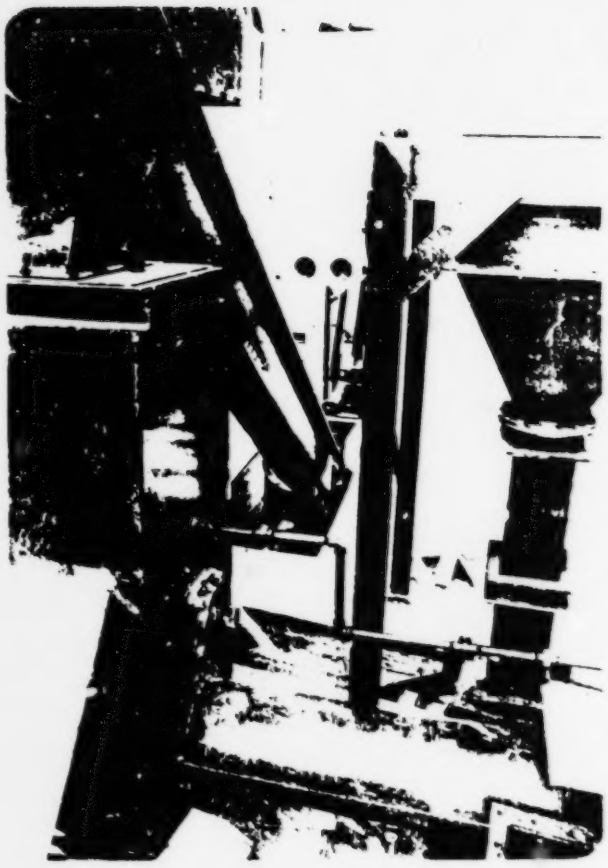


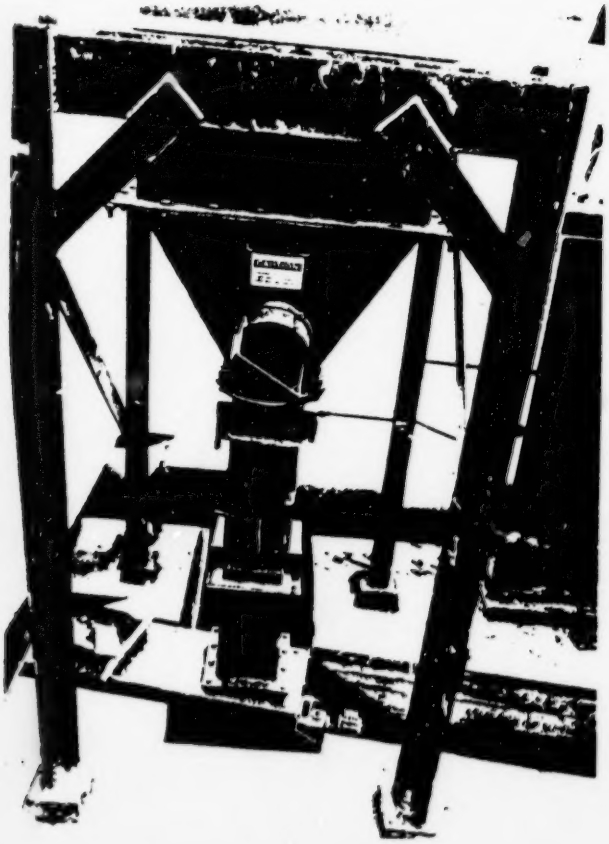
VIEW OF STORAGE BIN UNLOADING MECHANISM

DETAILS OF FLIGHTS IN BIN UNLOADING MECHANISM

OUTFEED STORAGE SCREW

OUTFEED STORAGE FEED SCREW / INCLINED SCREW
JUNCTION POINT

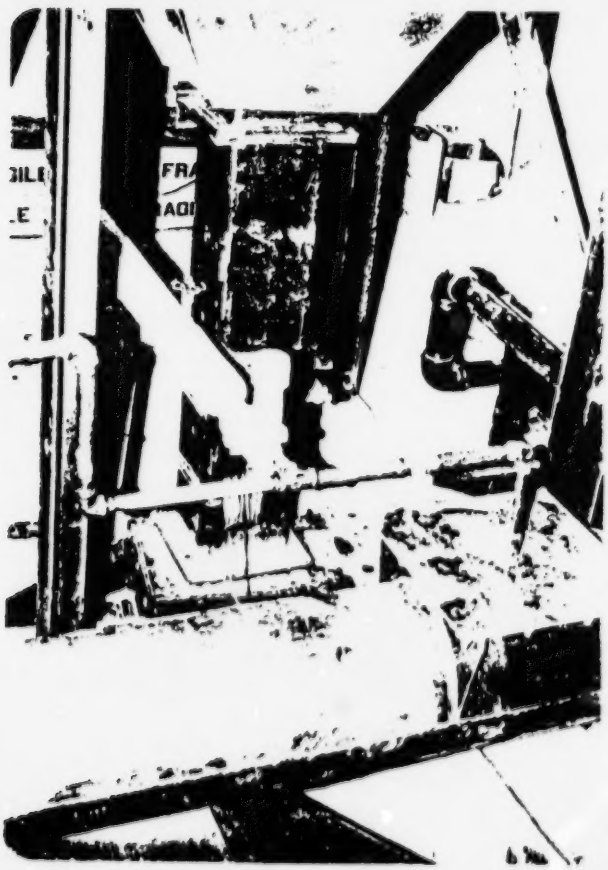




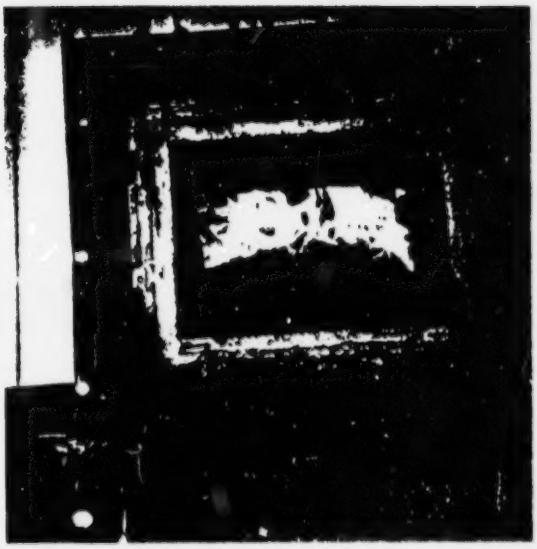
VIEW OF FLY ASH
COLLECTION HOPPER AND
ASH DISCHARGE SCREW

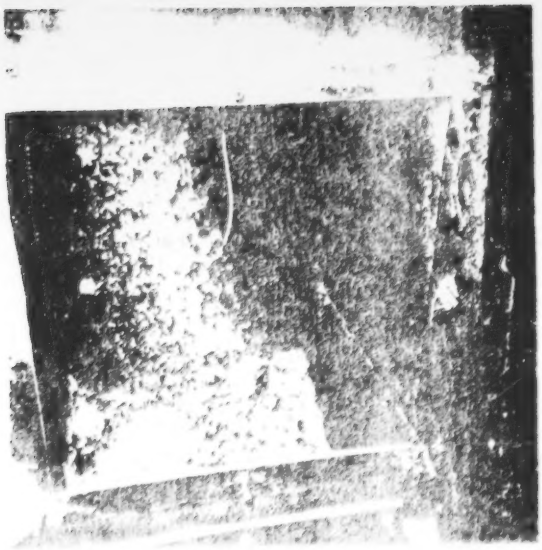
FUEL CELL AND BOILER

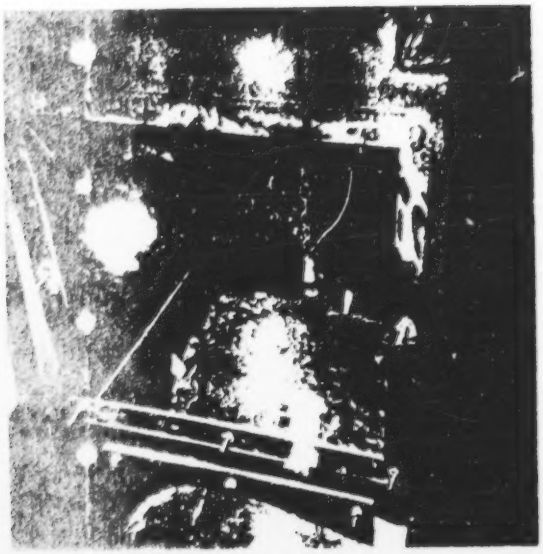
ASH DISCHARGE SCREW OUTSIDE BOILER HOUSE

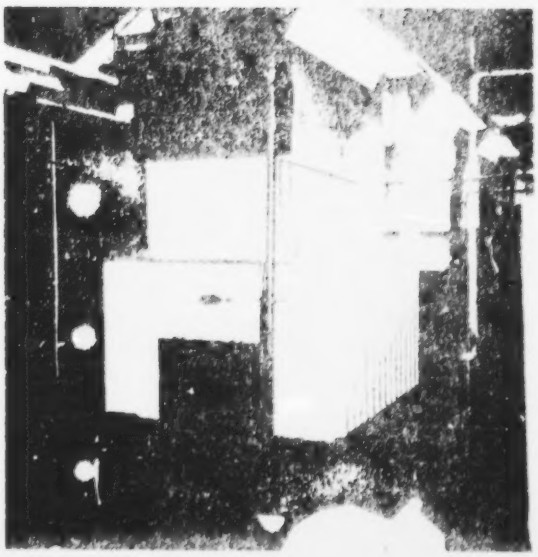


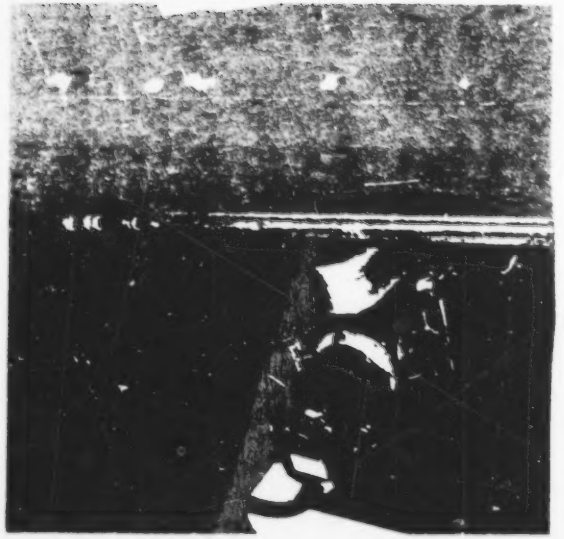
FIRE PROTECTION SYSTEM

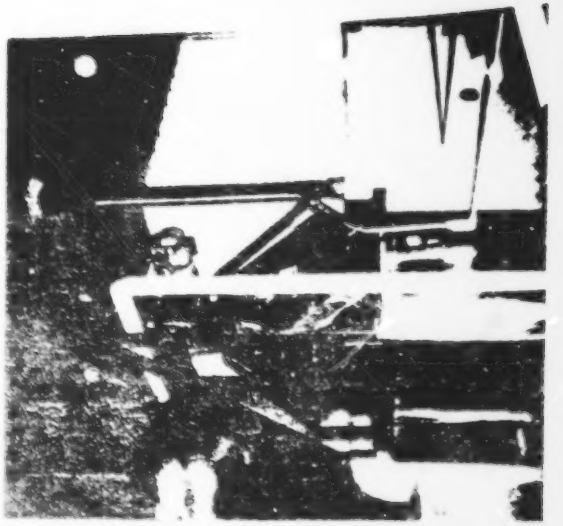












POOR

QUALITY

ORIGINAL